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6.3 GEOLOGIC HAZARDS AND RESOURCES

This section describes the geologic hazards and resources in the vicinity of the Project. The Site occurs in an area of relatively featureless terrain where the ground surface slopes gently northeast from the Kettleman Hills toward the San Joaquin Valley floor. The ground surface has been extensively disturbed by agricultural development. There will be no impacts from geologic hazards or to geologic resources of recreational, commercial or scientific value.

Geologic resources were assessed through a comprehensive review of literature pertaining to regional, local and site geology. This included an independent crosscheck for completeness against the California Division of Mines and Geology (CDMG) "Guidelines for Geologic/Seismic Considerations in Environmental Impact Reports, 1982." This literature review and analysis was complemented by site reconnaissance.

Beneficial aspects of the Project related to geologic resources are as follows:

- All surface disturbance is confined to areas of active agriculture.
- Plant construction will be completed in conformance with civil and structural engineering design criteria.
- Potential impacts in terms of geologic hazards will be controlled through appropriate building foundation and seismic structural design.

6.3.1 EXISTING CONDITIONS

6.3.1.1 Regional Geology

The Site is located within the southwestern portion of the San Joaquin Valley Geomorphic Province (see Figure 6.3-1). The San Joaquin Valley is a broad asymmetric structural trough bordered on the east by the Sierra Nevada Range and on the west by the coast ranges, including the Temblor Range in the south end of the valley and the Diablo Range near and north of the Site. The valley extends 250 miles southeastward from the confluence of the San Joaquin and Sacramento Rivers to the Tehachapi and San Emigdio Mountains (U.S. Geological Survey, 1973). The width of the valley ranges from 25 miles near the Kern River in the south end of the valley to 55 miles near the Kings River northwest of the Site.

Deep basement rock consists of Franciscan Complex, ultramaphic and basaltic rocks, and Sierra Nevada basement complex. The buried basement rock surface is a wide structural trough (Figure 6.3-2). The trough is infilled with marine and continental deposits derived largely from erosion of the mountain ranges on the sides of the valley. Beneath the Kettleman Hills, about 2 miles west of the Site, these marine and continental deposits are approximately 25,000 feet thick

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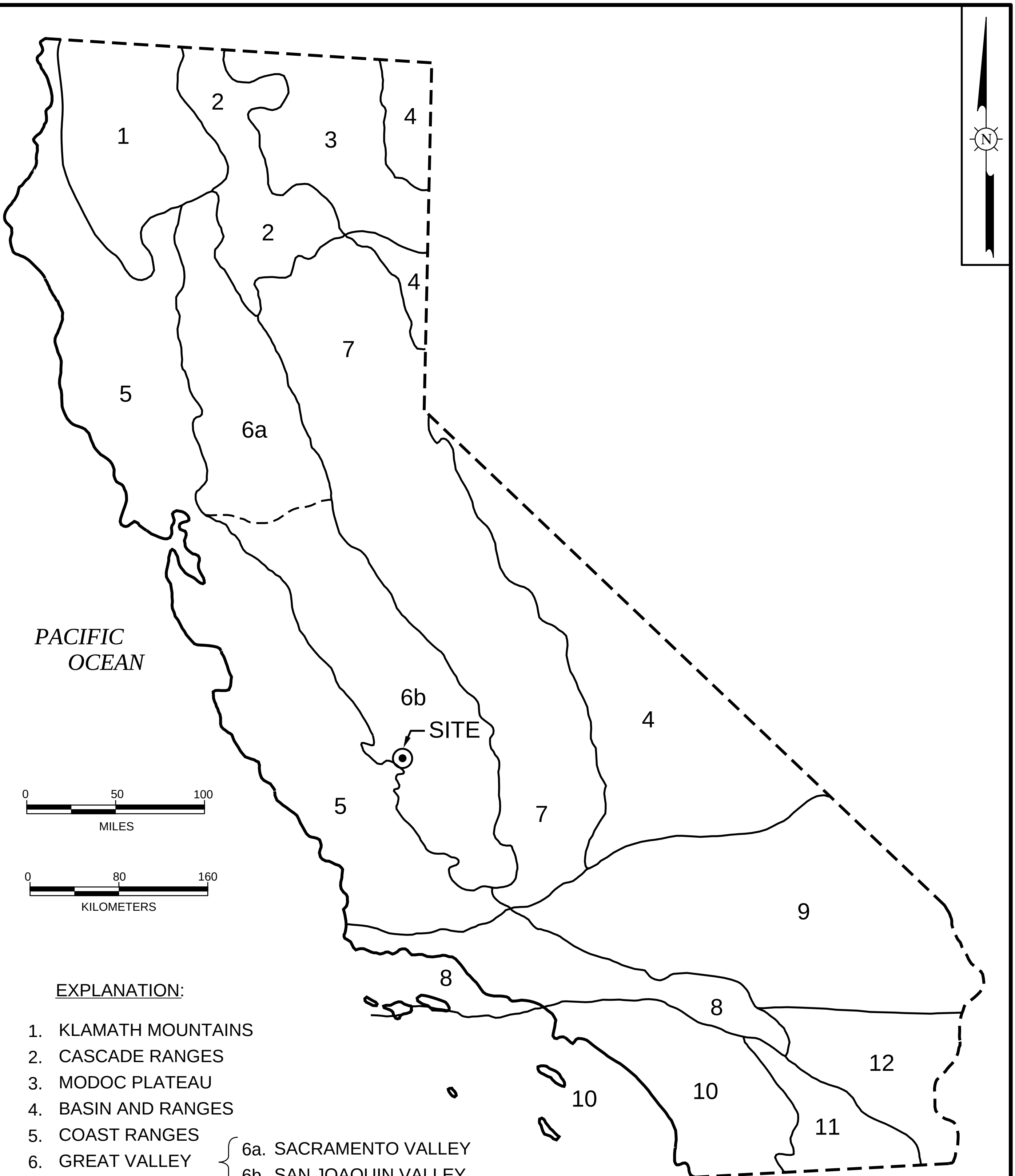

EXPLANATION:

1. KLAMATH MOUNTAINS
2. CASCADE RANGES
3. MODOC PLATEAU
4. BASIN AND RANGES
5. COAST RANGES
6. GREAT VALLEY
   - 6a. SACRAMENTO VALLEY
   - 6b. SAN JOAQUIN VALLEY
7. SIERRA NEVADA
8. TRANSVERSE RANGES
9. MOJAVE DESERT
10. PENINSULAR RANGES
11. SALTON TROUGH
12. COLORADO DESERT

SOURCE: MODIFIED AFTER NORRIS & WEBB, 1976

PHYSIOGRAPHIC PROVINCES OF CALIFORNIA

DUKE ENERGY AVENAL, LLC

AVENAL ENERGY	**FIGURE 6.3-1**

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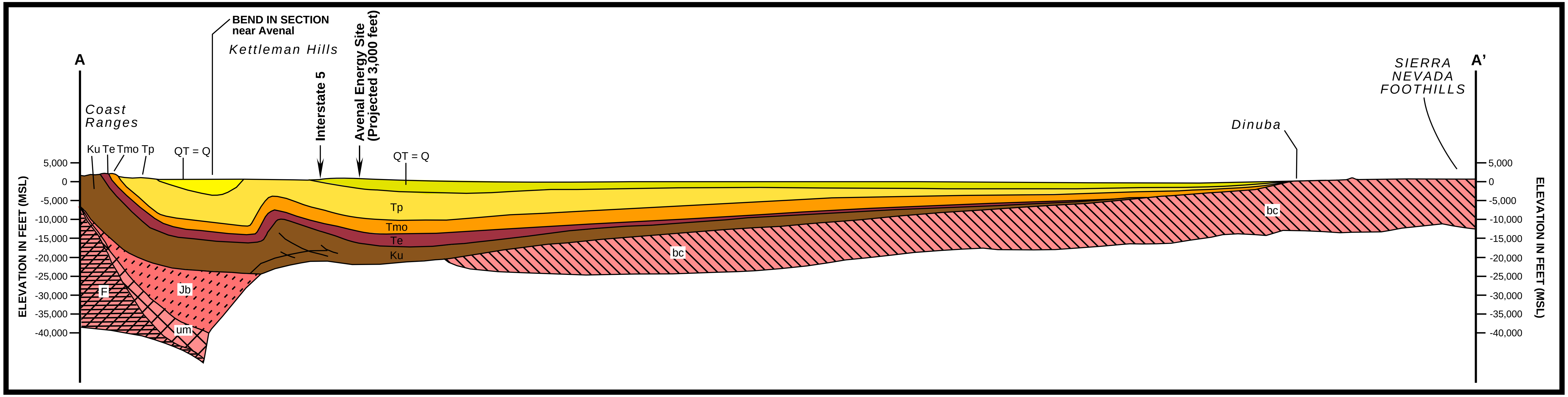

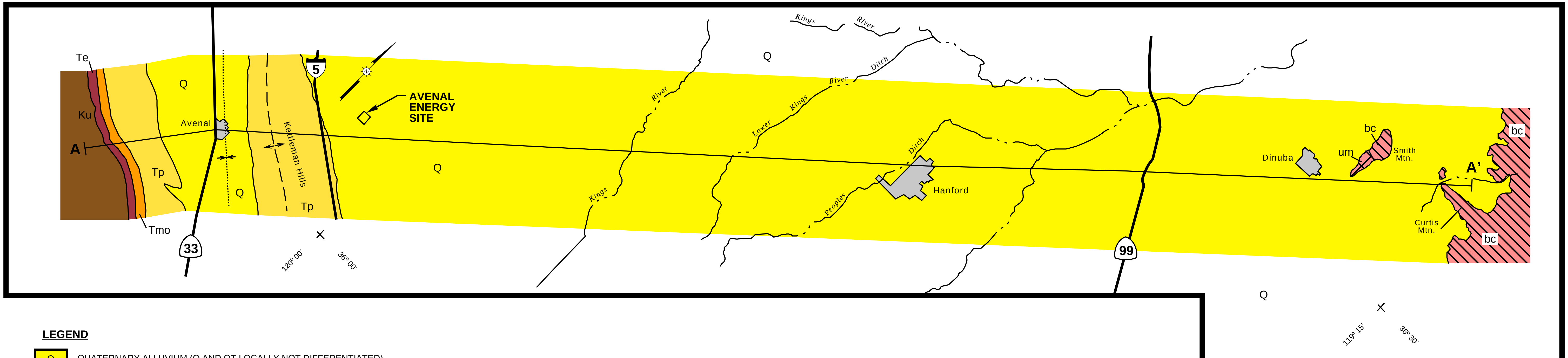

LEGEND

Q	QUATERNARY ALLUVIUM (Q AND QT LOCALLY NOT DIFFERENTIATED)
QT	PLIOCENE-PLEISTOCENE NONMARINE CLASTIC SEDIMENTS. TULARE FORMATION IN SAN JOAQUIN VALLEY.
Tp	PLIOCENE CLASTIC SHELF-TYPE SEDIMENTS, MAINLY MARINE. UPPER PART OF ETCHEGOIN AND SAN JOAQUIN FORMATIONS IN KETTLEMAN HILLS. NON-MARINE IN EASTERN SAN JOAQUIN VALLEY.
Tmo	MIOCENE AND OLIGOCENE SEDIMENTS. IN COAST RANGES, INCLUDES LOWER PART OF ETCHEGOIN FORMATION. IN SAN JOAQUIN VALLEY, INCLUDES MARINE CLASTIC SEDIMENTS OF TEMBLOR FORMATION (OLIGOCENE TO MIDDLE MIOCENE), SILICEOUS MCLURE SHALE, A MEMBER OF THE MONTEREY FORMATION (UPPER MIOCENE), AND MANY LOCAL UNITS. ALSO INCLUDES NON-MARINE. ZILCH FORMATION OF MALOVE (1962) IN EAST PART OF SAN JOAQUIN VALLEY.
Te	EOCENE AND PALEOCENE SEDIMENTS OF THE SAN JOAQUIN VALLEY, MAINLY MARINE, CLASTIC; LODO FORMATION (PALEOCENE AND LOWER EOCENE), AVENAL AND MCADAMS SANDSTONES (MIDDLE EOCENE), AND KREYENHAGEN SHALE (UPPER EOCENE
Ku	GREAT VALLEY SEQUENCE AND ITS COUNTERPARTS. MARINE CLASTIC SEDIMENTS; LARGELY DEEP-WATER TURBIDITES EXCEPT IN ZONE OF ONLAP ON SIERRAN BASEMENT. K, MAINLY CRETACEOUS, LOWER PART POSSIBLY UPPER JURASSIC (TITHONIAN) TO MID-CRETACEOUS.
Jb	UPPER JURASSIC BASALTIC ROCKS AT BASE OF GREAT VALLEY-TYPE SEDIMENTS. EXTRUSIVE BASALT AND MAFIC DIKE-AND-SILL COMPLEX CONSTITUTING OCEANIC CRUST UNIT OF SAN LUIS OBISPO (CUESTA RIDGE) OPHIOLITE.
bc	BASEMENT COMPLEX OF SIERRA NEVADA FOOTHILLS AND EASTERN SAN JOAQUIN VALLEY; INCLUDES QUARTZ DIORITE, MAFIC PLUTONIC ROCKS, SLATE, SCHIST, QUARTZITE, AND HORNBLENDE SCHIST. COULD BE PALEOZOIC TO UPPER JURASSIC.
F	FRANCISCAN COMPLEX. MELANGES AND COHERENT SANDSTONE UNITS. MELANGES CONTAIN BLOCKS OF GRAYWACKE, GREENSTONE, SERPENTINITE, CHERT, MINOR CONGLOMERATE, AND BLUESCHIST IN SHEARED ARGILLACEOUS MATRIX. ROCKS THAT OCCUR AS BLOCKS ARE LATE JURASSIC TO LATE CRETACEOUS IN AGE.
um	ULTRAMAFIC ROCKS, CHIEFLY SERPENTINIZED PERIODOTITE; LOCALLY ASSOCIATED WITH OPHIOLITE SUITES. SOME (OR ALL) ARE UPPER MANTLE MATERIAL. AGE UNKNOWN.

0 5 10 MILES
SCALE

SOURCE: ADAPTED FROM GEOLOGIC CROSS SECTION OF THE CONTINENTAL MARGIN OFF SAN LUIS OBISPO, THE SOUTHERN RANGES, AND THE SAN JOAQUIN VALLEY, CALIFORNIA. B.M. PAGE et. al. 1979.

REGIONAL GEOLOGIC CROSS SECTION

DUKE ENERGY AVENAL, LLC

AVENAL ENERGY | **FIGURE 6.3-2**

and range in age from present time to the Upper Cretaceous (63 to 96 million years before present) (Page et al., 1979). The lower (older) formations within these deposits are consolidated sedimentary rocks of marine origin that exist at depth throughout the valley and outcrop at the valley margins, including the Kettleman Hills (Figure 6.3-3A and B).

Within the valley, the lower marine formations are overlain by more poorly consolidated sediments of continental origin. In the vicinity of the Tulare Lake Bed and bordering areas, the change in depositional environment from predominantly marine to predominantly continental occurred during the Pliocene Epoch (2 to 5 million years before present) (Page, 1983). The thickness of the more poorly consolidated continental sediments deposited since that time varies from zero at the valley margins to more than 4,000 feet near the valley axis. These sediments include the Tulare Formation and other continental sediments that have accumulated as alluvial fan, deltaic, flood plain, lake and marsh deposits.

6.3.1.2 Local Geology

The Site occurs at the west side of the San Joaquin Valley, approximately 2 miles east of the Kettleman Hills. The Kettleman Hills occur where sediments of the Tulare and older formations that have been folded into an anticline are exposed at the surface (Figure 6.3-4). The folded sedimentary rocks dip down from the sides of the anticline into the valley, where they are buried by alluvial cover. Quaternary alluvium is the only geologic unit exposed in the Site vicinity. A 1:24,000 scale geologic map of the Site and surrounding area is provided in Figure 6.3-3C.

On the west side of the valley in the region of the Site, the Quaternary alluvium and the underlying Tulare Formation have similar characteristics. Beneath the Site, these units together comprise the interval from the surface to depths of approximately 2,000 to 2,800 feet (Page, 1983).

The Site region is comprised of farmland with thick alluvial cover and relatively featureless terrain. There are no geologic resources of recreational, commercial or scientific value in the Site vicinity.

6.3.1.3 Tectonic Framework

Within the San Joaquin Valley, known active faults are limited. The San Andreas Fault is the closest known active surface fault (Jennings, 1997), located approximately 40 kilometers (km) southwest of the Site at its closest point (Figure 6.3-3A). The San Andreas Fault is the dominant active tectonic feature of the coast ranges and represents the boundary of the North American and

Pacific tectonic plates. Right-lateral motion occurs along the San Andreas Fault at an average rate of 2.5 centimeters (cm) per year. Other surface faults shown in Figure 6.3-3 represent pre-Holocene faulting that is not known to be active. An active fault is one that shows clear evidence of movement within the Holocene Period (i.e., over the last 11,000 years) (Hart and Bryant, 1997).

The San Andreas Fault and related faults in the coast ranges are dominantly "strike-slip" faults where the earth's crust on one side of the fault moves in a dominantly lateral direction relative to the other side of the fault. A second style of active fault referred to as a "ramp thrust" also occurs in the region. Ramp thrust faults are low angle (subhorizontal) faults that occur deep below the ground surface and do not intersect the surface. Ramp thrust faults occur over relatively large areas due to their subhorizontal character. They occur where rock above the fault is being pushed over rock below the fault. Several segments of a ramp thrust fault occur beneath Coalinga and the Kettleman Hills and the adjacent margin of the San Joaquin Valley. The 1983 Coalinga earthquake (magnitude [M] 6.5) and the 1985 Kettleman Hills earthquake (M 5.9) are thought to have occurred on the Anticline Ridge segment and the Kettleman Hills segment of this ramp thrust fault, respectively. In the area of the Project Site, the ramp thrust fault is approximately 7.2 km below the ground surface **(**Peterson et al., 1996**)**. Because ramp thrust faults do not intersect the surface, there is no hazard related to surface displacement. Strong ground shaking can occur due to movement along these deeply buried faults.

6.3.1.4 Seismicity

Estimated locations of historical earthquakes of M 5.0 or greater within a 100-km radius of the Site for the period of 1800 through 2000 are shown in Figure 6.3-5. The epicenters of these earthquakes are predominantly associated with two fault systems: (1) the San Andreas Fault system, and (2) the Great Valley Fault system. The Great Valley Fault system is the blind ramp thrust fault system that occurs at depth throughout the Site vicinity, as described in Section 6.3.1.3. Table 6.3-1 summarizes the earthquakes with epicenters shown in Figure 6.3-5 that have magnitudes equal to or greater than 6.0. Table 6.3-1 also summarizes the closest historic epicenter, from an M 5.9 earthquake located approximately 10 km from the Site.

The EQFAULT computer program (Blake, 2000a) was used to deterministically assess the expected Site ground shaking initially due to seismic sources near the Site. The program provides an estimate of the Site peak horizontal ground acceleration due to the maximum earthquake (M_{max}) magnitude (also referred to as the Maximum Credible Earthquake [MCE]) for faults within a specified distance from the Site. The EQFAULT program utilizes the CDMG CDMG-1 USGS 1996 digital fault

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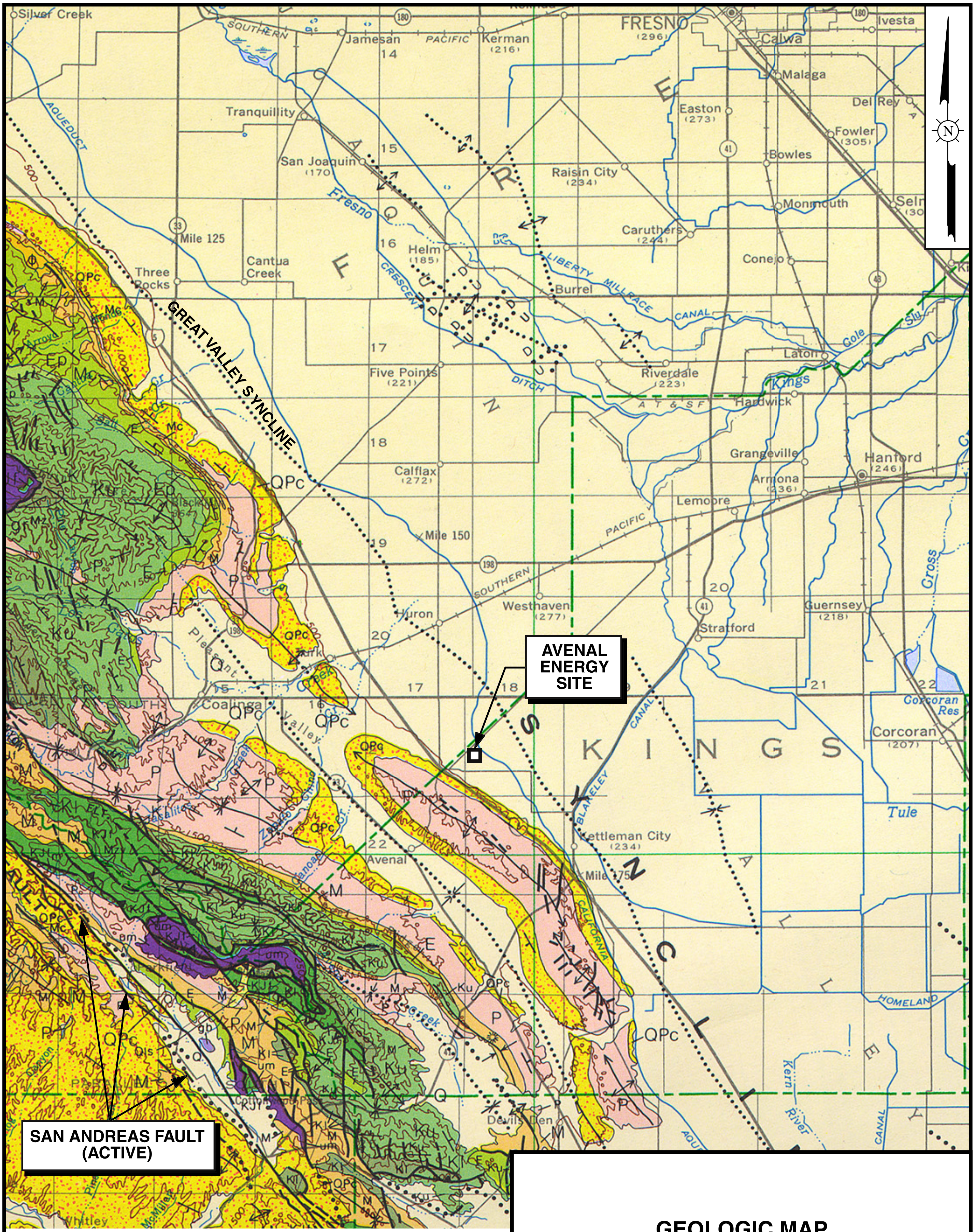

0 8 16 MILES

SCALE

SOURCE: JENNINGS, 1977.

GEOLOGIC MAP

DUKE ENERGY AVENAL, LLC

AVENAL ENERGY	FIGURE 6.3-3A

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GEOLOGIC LEGEND
(GENERALIZED DESCRIPTION OF ROCK TYPES)

CENOZOIC

MARINE SEDIMENTARY ROCKS

QUATERNARY — Pleistocene-Holocene

- Qs: Extensive marine and nonmarine sand deposits, generally near the coast or desert playas.
- Q: Alluvium, lake, playa, and terrace deposits; unconsolidated and semi-consolidated. Mostly nonmarine, but includes marine deposits near the coast.

TERTIARY

- P (Pliocene): Sandstone, siltstone, shale, and conglomerate; mostly moderately consolidated.
- M (Miocene): Sandstone, shale, siltstone, conglomerate, and breccia; moderately to well consolidated.
- Φ (Oligocene): Sandstone, shale, conglomerate; mostly well consolidated.
- E (Eocene): Shale, sandstone, conglomerate, minor limestone; mostly well consolidated.
- Ep (Paleocene): Sandstone, shale, and conglomerate; mostly well consolidated.

NONMARINE (CONTINENTAL) SEDIMENTARY ROCKS

- Qls: Selected large landslides, such as Blackhawk Slide on north side of San Bernardino Mountains; early to late Quaternary.
- Qg: Glacial till and moraines. Found at high elevations mostly in the Sierra Nevada and Klamath Mountains.
- QPc: Pliocene and/or Pleistocene sandstone, shale, and gravel deposits; mostly loosely consolidated.
- Mc: Sandstone, shale, conglomerate, and fanglomerate; moderately to well consolidated.
- Tc: Undivided Tertiary sandstone, shale, conglomerate, breccia, and ancient lake deposits.
- Φc: Sandstone, shale, and conglomerate; mostly well consolidated.
- Ec: Sandstone, shale, conglomerate; moderately to well consolidated.

VOLCANIC ROCKS

- Qrv: Recent (Holocene) volcanic flow rocks; minor pyroclastic deposits.
- Qrv^p: Recent (Holocene) pyroclastic and volcanic mudflow deposits.
- Qv: Quaternary volcanic flow rocks; minor pyroclastic deposits.
- Qv^p: Quaternary pyroclastic and volcanic mudflow deposits.
- Tv: Tertiary volcanic flow rocks; minor pyroclastic deposits.
- Tv^p: Tertiary pyroclastic and volcanic mudflow deposits.
- Ti: Tertiary intrusive rocks; mostly shallow (hypabyssal) plugs and dikes.

PLUTONIC ROCKS

- gr^{Ct}: Cenozoic (Tertiary) granitic rocks—quartz monzonite, quartz latite, and minor monzonite, granodiorite, and granite; found in the Kingston, Panamint, Amargosa, and Greenwater Ranges in southeastern California.

MESOZOIC, PALEOZOIC, PRECAMBRIAN

MARINE SEDIMENTARY AND METASEDIMENTARY ROCKS

- TK (TERTIARY–CRETACEOUS): Sandstone, shale, and minor conglomerate in coastal belt of northwestern California; included by some in Franciscan Complex. Previously considered Cretaceous, but now known to contain early Tertiary microfossils in places.
- Ku (CRETACEOUS): Upper Cretaceous sandstone, shale, and conglomerate.
- Kl (CRETACEOUS): Lower Cretaceous sandstone, shale, and conglomerate.
- K: Undivided Cretaceous sandstone, shale, and conglomerate; minor nonmarine rocks in Peninsular Ranges.
- KJf: Franciscan Complex: Cretaceous and Jurassic sandstone with smaller amounts of shale, chert, limestone, and conglomerate. Includes Franciscan mélange, except where separated-see KJf_m.
- KJf_m: Mélange of fragmented and sheared Franciscan Complex rocks.
- KJf_s: Blueschist and semi-schist of Franciscan Complex.
- J (JURASSIC): Shale, sandstone, minor conglomerate, chert, slate, limestone; minor pyroclastic rocks.
- Tr (TRIASSIC): Shale, conglomerate, limestone and dolomite, sandstone, slate, hornfels, quartzite; minor pyroclastic rocks.
- sch: Schists of various types; mostly Paleozoic or Mesozoic age; some Precambrian.
- ls: Limestone, dolomite, and marble whose age is uncertain but probably Paleozoic or Mesozoic.
- Pm (PERMIAN): Shale, conglomerate, limestone and dolomite, sandstone, slate, hornfels, quartzite; minor pyroclastic rocks.
- C (CARBONIFEROUS): Shale, sandstone, conglomerate, limestone, dolomite, chert, hornfels, marble, quartzite; in part pyroclastic rocks.
- Pz: Undivided Paleozoic metasedimentary rocks. Includes slate, sandstone, shale, chert, conglomerate, limestone, dolomite, marble, phyllite, schist, hornfels, and quartzite.
- D (DEVONIAN): Limestone and dolomite, sandstone and shale; in part tuffaceous.
- SO (SILURIAN–ORDOVICIAN): Sandstone, shale, conglomerate, chert, slate, quartzite, hornfels, marble, dolomite, phyllite; some greenstone.
- Є (CAMBRIAN): Sandstone, shale, limestone, dolomite, chert, quartzite, and phyllite; includes some rocks that are possibly Precambrian.
- pЄ (PRECAMBRIAN): Conglomerate, shale, sandstone, limestone, dolomite, marble, gneiss, hornfels, and quartzite; may be Paleozoic in part.

MIXED ROCKS

- gr-m: Granitic and metamorphic rocks, mostly gneiss and other metamorphic rocks injected by granitic rocks. Mesozoic to Precambrian.
- m: Undivided pre-Cenozoic metasedimentary and metavolcanic rocks of great variety. Mostly slate, quartzite, hornfels, chert, phyllite, mylonite, schist, gneiss, and minor marble.
- pЄc: Complex of Precambrian igneous and metamorphic rocks. Mostly gneiss and schist intruded by igneous rocks; may be Mesozoic in part.

METAVOLCANIC ROCKS

- Mzv: Undivided Mesozoic volcanic and metavolcanic rocks. Andesite and rhyolite flow rocks, greenstone, volcanic breccia and other pyroclastic rocks; in part strongly metamorphosed. Includes volcanic rocks of Franciscan Complex: basaltic pillow lava, diabase, greenstone, and minor pyroclastic rocks.
- mv: Undivided pre-Cenozoic metavolcanic rocks. Includes latite, dacite, tuff, and greenstone; commonly schistose.
- Pzv: Undivided Paleozoic metavolcanic rocks. Mostly flows, breccia, and tuff, including greenstone, diabase and pillow lavas; minor interbedded sedimentary rocks.

PLUTONIC ROCKS

- gr^{Mz}: Mesozoic granite, quartz monzonite, granodiorite, and quartz diorite.
- um: Ultramafic rocks, mostly serpentine. Minor peridotite, gabbro, and diabase. Chiefly Mesozoic.
- gb: Gabbro and dark dioritic rocks; chiefly Mesozoic.
- gr: Undated granitic rocks.
- gr^{Pz}: Paleozoic and Permo-Triassic granitic rocks in the San Gabriel and Klamath Mountains
- $gr^{pЄ}$: Precambrian granite, syenite, anorthosite, and gabbroic rocks in the San Gabriel Mountains; also various Precambrian plutonic rocks elsewhere in southeastern California.

SOURCE: JENNINGS, 1977.

GEOLOGIC MAP LEGEND

DUKE ENERGY AVENAL, LLC

AVENAL ENERGY | FIGURE 6.3-3B

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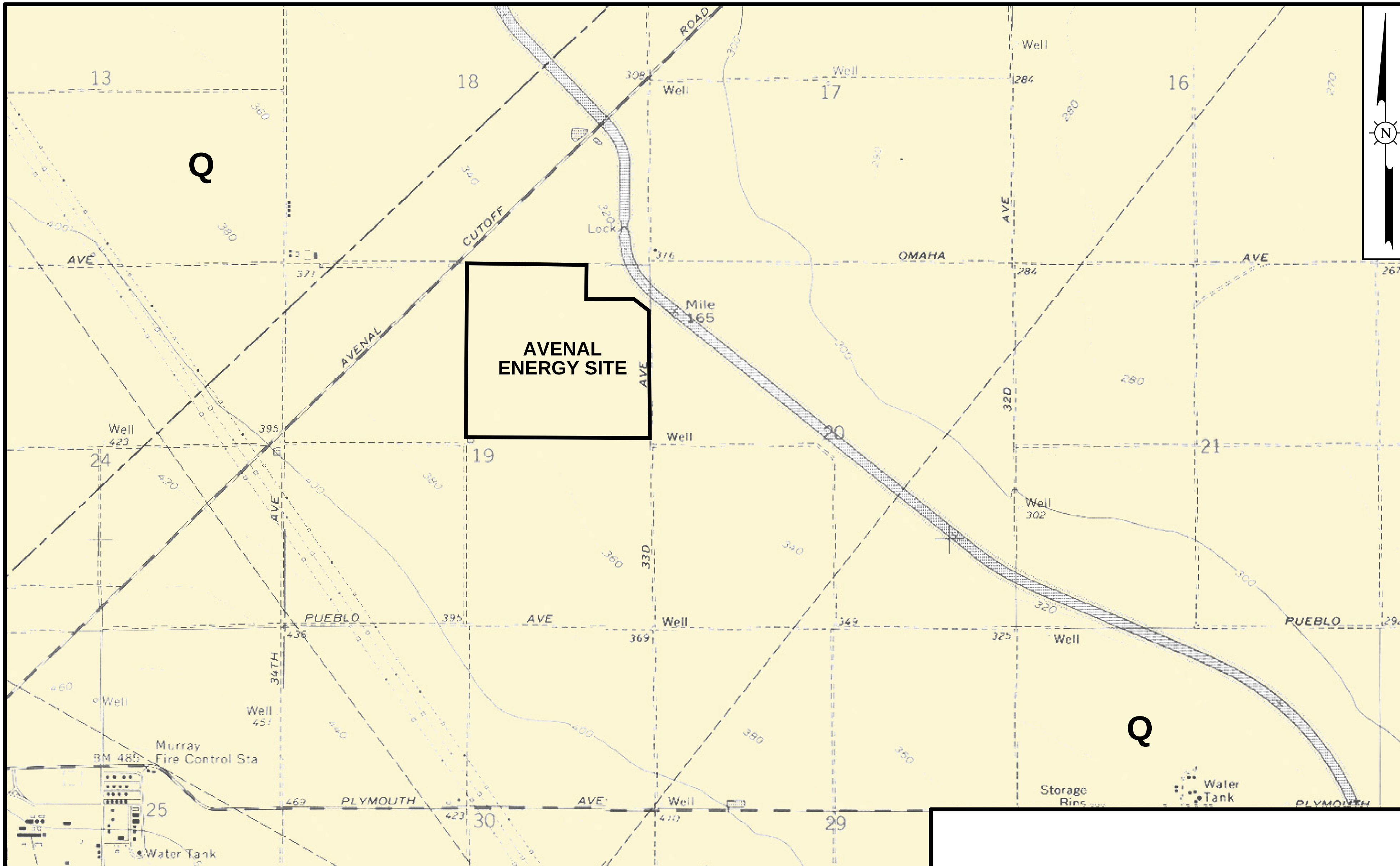


LEGEND

Q	QUATERNARY ALLUVIUM

0 2,000 4,000 FEET

SCALE

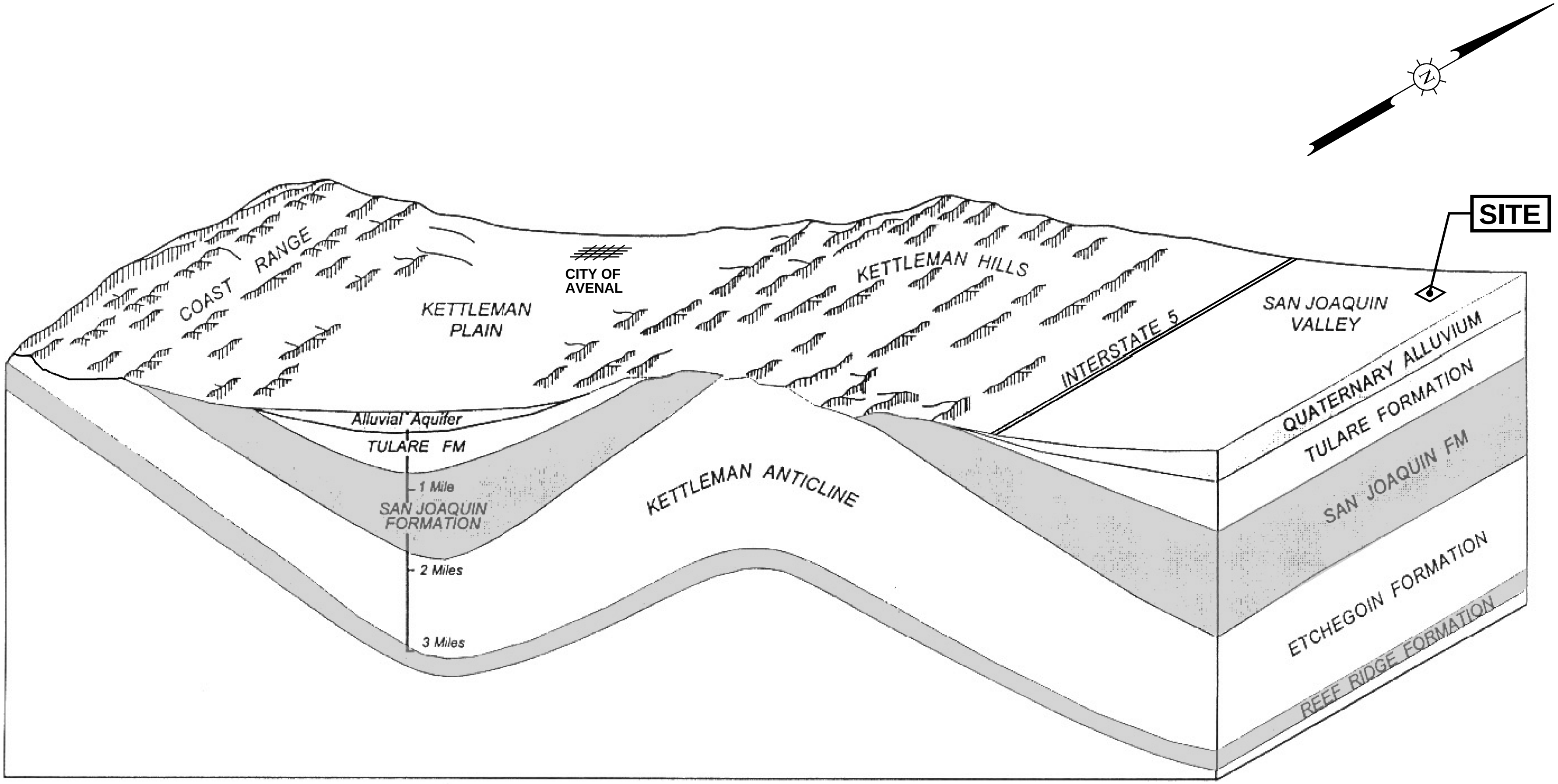
REFERENCE: U.S.G.S 7.5 MINUTE TOPOGRAPHIC SERIES MAP OF LA CIMA, CALIFORNIA, DATED 1978.

1:24,000 GEOLOGIC MAP

DUKE ENERGY AVENAL, LLC

AVENAL ENERGY

FIGURE 6.3-3C



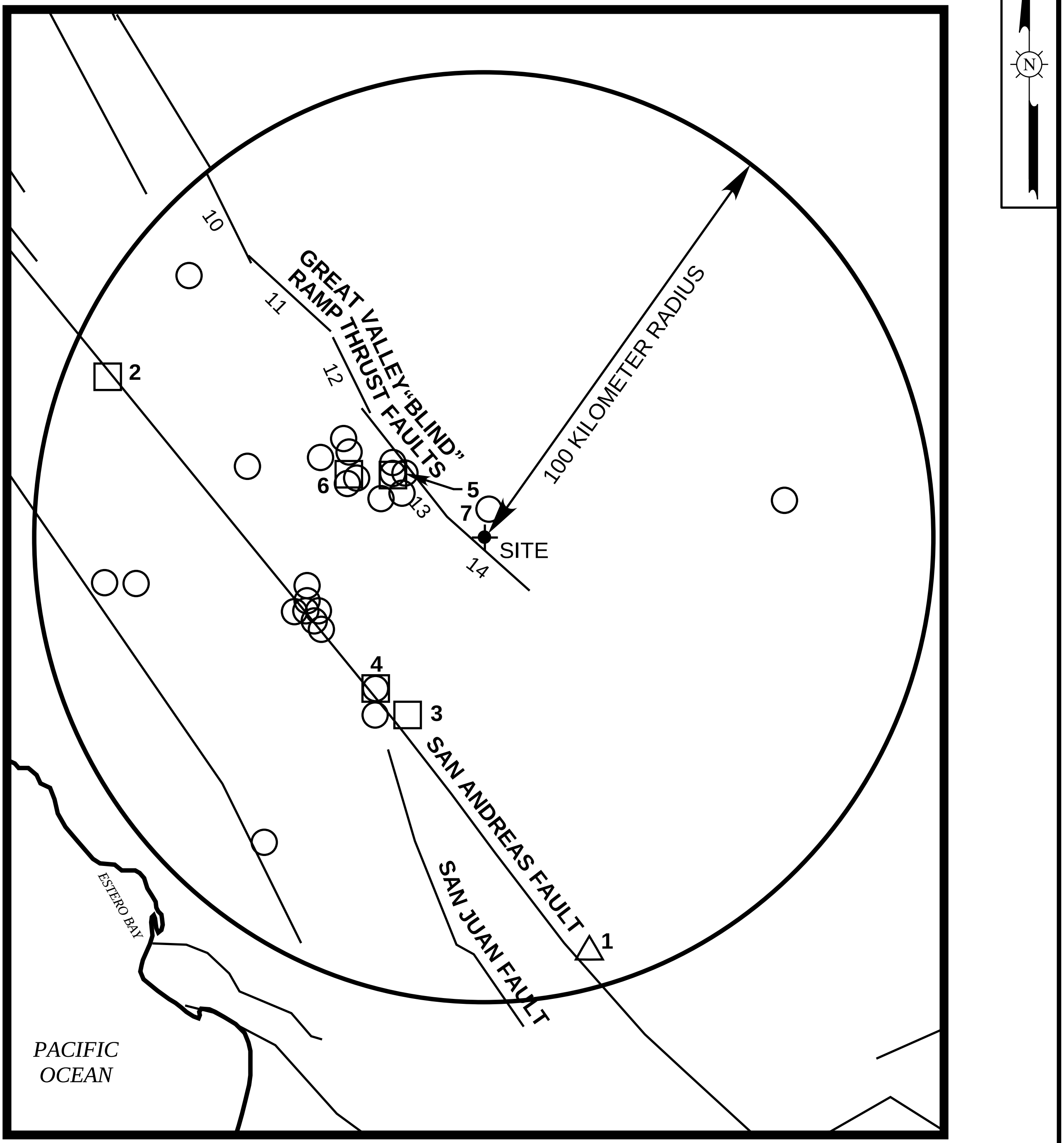
NOT TO SCALE

SOURCE: MODIFIED AFTER EINARSON, FOWLER & WATSON, OCTOBER 1996.

NORTH DOME ANTICLINE

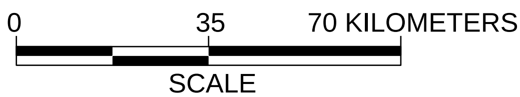
DUKE ENERGY AVENAL, LLC

AVENAL ENERGY	**FIGURE 6.3-4**



LEGEND

- △ M = 7.0 - 7.9
- □ M = 6.0 - 6.9
- ○ M = 5.0 - 5.9
- 4 EVENT No. CORRESPONDING TO TABLE 6.3-1



REFERENCE: COMPUTERIZED EARTHQUAKE CATALOG OF CALIFORNIA, (EQSEARCH, 2000)

HISTORICAL EARTHQUAKE EPICENTER AND MAGNITUDE MAP PERIOD: 1800 TO 2000, MAGNITUDE ≥ 5

DUKE ENERGY AVENAL, LLC

AVENAL ENERGY	**FIGURE 6.3-5**

TABLE 6.3-1

HISTORICAL EARTHQUAKES OF MAGNITUDE 6.0 AND GREATER, 1800 TO 2000 (WITHIN 100 KILOMETERS)

EVENT NO. (1)	DATE	MAGNITUDE	APPROXIMATE LOCATION	DISTANCE FROM SITE	ASSOCIATED FAULT OR STRUCTURE
1	January 9, 1857	7.9	44 miles west of Bakersfield (35.3°N, 119.6°W)	93 km	San Andreas, Cholame Segment
2	April 12, 1885	6.2	53 miles east of Carmel Bay and 72 miles southwest of Fresno (36.4°N, 121.0°W)	91 km	San Andreas Fault
3	March 10, 1922	6.5	40 miles east of Lake Nacimiento (35.75°N, 120.25°W)	43 km	San Andreas Fault
4	June 8, 1934	6.0	34 miles east of Lake San Antonio (35.8°N, 120.33°W)	41 km	San Andreas Fault
5	May 2, 1983	6.7	46 miles southwest of Fresno (36.22°N, 120.29°W)	25 km	Great Valley 13 Fault, Coalinga Earthquake
6	July 22, 1983	6.0	50 miles southwest of Fresno (36.22°N, 120.4°W)	33 km	Great Valley 13
7	August 4, 1985	5.9 (2)	47 miles southwest of Fresno (36.12°N, 120.15°W)	10 km	Great Valley 14 Fault - Kettleman Hills Earthquake

31161 Rpts/AFC/Tbls&Figs (9/25/01/jb))

(1) Corresponds with Figure 6.3-5.
(2) Included due to proximity to the Site.

Reference: Blake, 2000.

database. The CDMG is the state agency responsible for mapping and documenting the location of active faults in California. Table 6.3-2 summarizes the key faults and fault parameters derived from the EQFAULT program for maximum earthquake events of the faults within a 100-km radius of the Site. Based on this analysis, the M_{max} peak horizontal site ground acceleration is 0.47 g from an M 6.4 earthquake on the blind ramp thrust fault (Great Valley Fault System) that occurs approximately 7.2 km below the ground surface in the Site vicinity.

As shown in Table 6.3-2, although the San Andreas Fault is capable of generating a much larger earthquake, its distance from the Site results in substantial attenuation of earthquake energy and, consequently, less potential ground shaking at the Site.

6.3.1.5 Geologic Hazards

The following sections address geologic hazards in accordance with CCR Title 20, Appendix B requirements. Surface water conditions and flood zone classification are discussed in Section 6.5 - Water Resources.

6.3.1.5.1 Ground Rupture

As previously discussed, there are no active faults that intersect the ground surface in the vicinity of the Site. The closest active surface fault is the San Andreas Fault located approximately 40 km southwest of the Site at its closest point. Consequently, surface fault rupture is not a hazard to the Project.

6.3.1.5.2 Ground Shaking

The Site, like much of California, is located within a seismically active area. Therefore, the potential for future earthquakes in the vicinity within the lifetime of the Project is high. As discussed in Section 6.3.1.4, the degree of ground shaking anticipated at the Site was assessed deterministically using the computer program EQFAULT, and the M_{max} peak horizontal site ground acceleration was estimated to be 0.47 g from an M 6.4 earthquake on the ramp thrust fault that occurs below the Site (see Table 6.3-2). The M_{max} is the largest earthquake that could occur on a fault based on the known tectonic framework.

The CBC will require that Project structures be designed with adequate strength to withstand the lateral dynamic displacements induced by the Design Basis Ground Motion, which the CBC defines as the earthquake ground motion that has a 10 percent chance of being exceeded in 50 years.

TABLE 6.3-2

ESTIMATED SEISMIC PARAMETERS FOR FAULTS WITHIN 100 KILOMETERS

FAULT	DISTANCE FROM SITE (km)	MAXIMUM EARTHQUAKE MAGNITUDE (M_{max})	ESTIMATED PEAK HORIZONTAL GROUND ACCELERATION AT SITE (g)
Great Valley (Segment 14)	7.2	6.4	0.47
Great Valley (Segment 13)	11.7	6.5	0.31
Great Valley (Segment 12)	37.3	6.3	0.10
San Andreas (1857 Rupture)	39.4	7.8	0.18
San Andreas (Parkfield Segment)	39.4	6.7	0.10
San Andreas (Chalome)	43.8	6.9	0.10
San Juan	50.8	7.0	0.1

31161 Rpts/AFC/Tbls&Figs (10/4/01/ks)

NOTE: Fault information is obtained from CDMG data base (http://www.consrv.ca.gov/dmgl), DMG Open File Report 96-08/USGS Open-File Report 96-706 (1996) and EQFAULT (Blake, 2000a).

The Site is within CBC Seismic Zone 4, where the minimum acceptable horizontal acceleration coefficient for earthquake-resistant structural design is 0.4 g.

6.3.1.5.3 Tsunami/Seiche

The Site region is inland and protected from the ocean by the coast ranges, and there are no large water bodies upslope. Consequently, tsunami or seiche is not a hazard to the Project. In the event of strong groundshaking a seiche could occur from the canal, but a seiche from the canal would not be a hazard to the Project because the narrow configuration of the canal would limit the volume of any seiche directed toward the Site and because the Site is upgradient from the canal.

6.3.1.5.4 Mass Wasting and Slope Stability

The Site is located on a relatively featureless topography overlying alluvial sediments. Topography at the Site is essentially flat except for a gentle slope toward the northeast. This subdued site topography is not susceptible to landslides or other forms of slope instability.

6.3.1.5.5 Liquefaction

Liquefaction is the loss of soil shear strength due to increased pore water pressure from ground shaking generated during earthquakes. The liquefaction potential at a given site is usually evaluated through geotechnical investigations that assess earthquake sources, soil type, soil density and depth to groundwater.

The two primary conditions required for liquefaction potential are:

- Presence of low density silt and sand.
- Shallow groundwater within 30 to 50 feet of the ground surface.

As further discussed in Section 6.5, groundwater occurs hundreds of feet below the ground surface at the Site. Consequently, liquefaction is not expected to be a hazard to the Project. Geotechnical studies will be conducted as part of Project siting design to confirm the low potential for liquefaction.

6.3.1.5.6 Subsidence

Subsidence due to groundwater withdrawal was a problem throughout much of the San Joaquin Valley in the decades prior to the 1970s. Since that time, the availability of a surface water supply and decrease in groundwater pumping has reduced groundwater overdraft and water levels in the aquifer have recovered stabilizing the primary subsidence mechanism. As discussed in Section 6.5, the Project will not increase groundwater withdrawal and, consequently, will not result in subsidence.

6.3.1.5.7 Expansive Soils

Soils in the Project vicinity consist of a sandy loam. This sandy material does not pose an expansive soil hazard.

6.3.1.6 Geologic Resources of Recreational, Commercial or Scientific Value

There are no geologic resources of recreational, commercial or scientific value that might be affected by the Project. This is based on literature searches, site reconnaissance and review of local land use planning documents. The Site is located in featureless terrain in an agricultural area. Soils are thick, bedrock is deep, and there are no unique geologic or landform features in the Site vicinity.

6.3.2 IMPACTS

Significance criteria were determined based on CEQA Guidelines, Appendix G, Environmental Checklist Form (amended December 1, 1999), and on performance standards or thresholds adopted by responsible agencies. An impact may be considered significant if the Project results in:

- Severe damage or destruction to one or more project components as a direct consequence of a geologic event.
- Release of toxic or other damaging material into the environment as a result of a geologic event.
- Exposure of people or structures to potential substantial adverse effects, including the risk of loss, injury or death involving:
  - Rupture of a known earthquake fault.
  - Strong seismic ground shaking.
  - Seismic-related ground failure, including liquefaction.
  - Inundation by seiche, tsunami or mudflow.
  - Landslides.
  - Flooding.
  - Loss of a unique geologic feature.
- Loss of availability of a known mineral resource classified as MRZ-2 by the state geologist and of value to the region and the residents of the state.
- Loss of availability of a locally important mineral resource recovery site.

6.3.2.1 Construction Impacts

Given the short period of construction relative to the recurrence interval of large earthquakes, the probability of significant ground shaking occur at the Site during the construction period is low. No impact to construction is expected.

There are no geologic hazards other than ground shaking that may impact construction. As discussed in Section 6.3.1.5, ground surface rupture, tsunami, seiche, slope instability, liquefaction and expansive soils do not pose a hazard at the Site.

6.3.2.2 Operations and Maintenance-Related Impacts

The Site is located in a seismically active area. Consequently, there is a reasonable likelihood of ground shaking at the Site within the lifetime of the facility. As described in Section 6.3.1.5.2, the CBC will require that Project structures be designed with adequate strength to withstand earthquake ground motion that has a 10 percent chance of being exceeded in 50 years, which is longer than the anticipated Project life. The likelihood of the Design Basis Ground Motion being exceeded during the life of the Project is less than 10 percent. The Project foundations and structures will be designated and constructed to limit ground shaking impacts to a level that is less than significant.

No other geologic hazards have a significant likelihood of affecting the Project. As discussed in Section 6.3.1.5, the Site is not susceptible to ground surface rupture, tsunami, seiche, slope instability, liquefaction or expansive soils.

There will be no operations impacts to geologic resources. The Site occurs in an area of relatively featureless topography and Quaternary alluvium is the only geologic unit exposed within approximately 2 miles. The ground surface has been extensively disturbed by agricultural activities. No unique or valuable geologic or mineral resources will be affected.

6.3.2.3 Cumulative Impacts

Other activities in the region with potential for cumulative impacts identified in Section 6.1.4. Based on the analysis provided in Section 6.3.2.1 and 6.3.2.2, the Project will not impact geologic resources. Therefore, there is no potential for cumulative impacts to geologic resources. Potential geologic impacts to the Project, as described in Section 6.3.2.1 and 6.3.2.2, are site-specific and to not have the potential to be cumulative. For example, the affects of potential ground shaking on the Project (or any other activity) are not additive with any other activity. Therefore, there will be no cumulative geologic impact to the Project or to other activities in the region.

6.3.2.4 Project Design Features

The following design and/or operational features of the Project avoid potentially significant geologic hazard and resource impacts and have been incorporated into the Project:

- An engineering geology report will be developed as part of Project siting design. The report will be developed in conformance with the current CBC. The report will be developed, signed and stamped by a California Certified Engineering Geologist. Final placement and design of the proposed facilities and foundations will follow the recommendations of the engineering geology report.
- Since the Site is located in a seismically active area, a detailed, site-specific seismic evaluation will be performed as part of Project siting design. This evaluation will determine the governing design ground acceleration, and will be coordinated with power plant structural design, as needed, to control any potential impacts associated with ground shaking, in accordance with the CBC. The proposed facilities will be designed in accordance with CBC Seismic Zone 4.

6.3.3 MITIGATION MEASURES

Based on the above analysis of impacts and the design and operational features that have been incorporated into the Project, no mitigation measures are required.

6.3.4 SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

There are no significant unavoidable adverse impacts from geologic hazards or to geologic resources from Project construction or operations.

6.3.5 LAWS, ORDINANCES, REGULATIONS AND STANDARDS (LORS)

LORS related to geologic hazards and resources are listed in Table 6.3-3 along with names of the administering agencies and the Project's approach to compliance. The Project will comply with applicable LORS during Project construction and operation.

The Site is not located within an Alquist-Priolo Special Studies Zone. Therefore, the Project will not be subject to restrictions relative to active faults. No site-specific fault studies are required.

The Site is in the CBC Seismic Zone 4; the requirements included in the CBC for Zone 4 apply to the Project. Relevant requirements include designing structures with adequate strength to withstand earthquake ground motion that has a 10 percent chance of being exceeded in 50 years, with a

TABLE 6.3-3

GEOLOGIC HAZARDS AND RESOURCES LORS AND COMPLIANCE

JURIS-DICTION	LORS/AUTHORITY	ADMINISTERING AGENCY[1]	REQUIREMENTS/ COMPLIANCE	APPROACH TO COMPLIANCE	AFC SECTION
Federal	None applicable.	None applicable.	None applicable.	None applicable.	None applicable.
State	PRC 25523(a); 20 CCR §1752(b),(c)	California Energy Commission through its Chief Building Official(CBO).	Restricts building relative to seismicity.	Avenal Energy will be designed to meet Seismic Zone 4 requirements. Detailed seismic evaluations will be completed.	Sections 6.3.1.5, 6.3.2.2, 6.3.2.4, 6.3.5 Pages 6.3-16, 6.3-20, 6.3-21
	California Building Code (CBC) and Uniform Building Code (UBC) Chapter 33.	City of Avenal Planning Department.	Control excavation, grading, and construction to safeguard life and property.	Performance of Foundation investigation and detailed evaluation of subsurface soils.	Sections 6.3.2.4, 6.3.5 Pages 6.3-21
Local	None applicable.	None applicable.	None applicable.	None applicable.	None applicable.
Industry	None applicable.	None applicable.	None applicable.	None applicable.	None applicable.

31161 Rpts/AFC/Tbls&Figs (10/4/01/mc)

(1) Pursuant to CCR Title 20, Appendix B(h)(1)(B): Each agency with jurisdiction to issue applicable permits and approvals or to enforce identified laws, regulations, standards, and adopted local, regional, state and federal land use plans, and agencies which would have permit approval or enforcement authority, but for the exclusive authority of the Commission to certify sites and related facilities.

minimum acceptable horizontal acceleration coefficient of 0.4g. The administering agency for the above authority is the Commission.

The Project will comply with applicable building codes to address power plant foundation and seismic structural design. Engineering design criteria, which include building code compliance features, are provided in Engineering Appendices 2-1 and 2-2.

There are no permits or approvals required for the Project related to geology that are outside the jurisdiction of the Commission. If not for the authority of the Commission to certify sites, the Project would require grading and building permits from the City of Avenal. The City will review plans for the Project, including the engineering geology report, and will be the administering agency for conformance with UBC and CBC. Contact information for the City of Avenal is provided in Table 6.3-4.

TABLE 6.3-4

AGENCY CONTACTS FOR GEOLOGIC RESOURCES

AGENCY AND CONTACT	PERMITTING/APPROVAL AUTHORITY
Jim Doughty Director of Planning and Development City of Avenal 919 Skyline Blvd. Avenal CA 93204 (559) 386-5766	Administering Agency for UBC and CBC is the Commission through the CBO, which is expected to be the City of Avenal.

6.3.6 REFERENCES

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